Final Report
ONR Contract N00014-94-1-0576

"Building Simulations for Virtual Environments"

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Contract Title: Building Simulations for Virtual Environments
Contract Number: N00014-94-1-0576
Reporting Period: April 1994 through February 1996
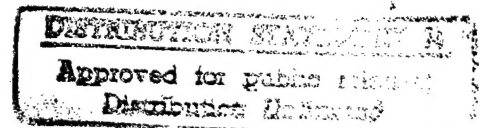
1   Productivity Measures

Refereed papers published: 7

Unrefereed reports and articles: 2

Books or parts thereof published: 5

Patents filed but not yet granted: none

Patents granted (include software copyrights): none

Invited presentations: 7

Contributed presentations: 1

Editorial Boards Service (Hoffmann):

   ACM Transactions on Graphics; 1995–
   Advances in Computational Mathematics; 1992–95
   Computer Aided Design; 1996–
   Computer Aided Geometric Design; 1990–
   Computer Graphics Forum; 1992–
   CVGIP: Graphical Models and Image Processing; 1994–
   Intl. J. of Comp. Geometry and Applications; 1991–
   Journal for Applicable Algebra; 1989–
   Journal for Symbolic Computation; 1989–
   SIAM Monographs in Science and Engineering; 1994–

Graduate students supported:

   Carlos Gonzalez-Ochoa, PhD expected in 1998.

Haitao Jiang, MS 1996
Ramanathan Kavasseri, MS 1996, with Cisco Systems
Cassiano Durand, PhD expected 1998

2   Summary of Activities

The contract was awarded to Dr. George Vanecek. When Dr. Vanecek left Purdue University, to join AT&T, the contract was re-assigned to Professor Hoffmann. The work under this contract has focused on two efforts:

(A) The Proxima project of Dr. Vanecek, simulating virtual mechanical systems of and the required spatial geometric computations.

(B) The Erep project of Dr. Hoffmann developing a neutral CAD representation supporting features and constraints.

(A)   Project Proxima (Vanecek)

This effort is a continuation of the highly successful Project Newton sponsored by ONR (N00014-86-K-0465 and N00014-90-J-1599). Newton was a collaboration between John Hopcroft, Cornell, and Christoph Hoffmann, Purdue. The objective of the Newton effort has been the creation of a system for simulating the dynamical behavior of mechanisms and mechanically evolving environments.

The objective of Proxima was to create infrastructure and environments for rapid creation of mechanical simulations and virtual environments, with special emphasis on distance computations and collision detection and analysis. Proxima also had collaborative ties with Jim Cremer, University of Iowa, who was also supported by ONR.

The creation of geometric models for virtual worlds is a primary difficulty addressed by Proxima. To this end, special data structure were developed and implemented for computing the proximity of objects and for determining near features between objects that are close. The publications resulting from this work are listed below. The Proxima toolkit was implemented in C++.

As part of the effort, Dr. Vanecek organized a workshop at Purdue on *Simulation of Virtual Environments*, July 1994, jointly with Professor Cremer from the University of Iowa. Due to the success of the workshop, a second workshop was organized at the University of Iowa on *Simulation and Interaction in Virtual Environments*. Co-chairs of the second workshop were Professor Cremer from the University of Iowa and Professor Manocha from the University of North Carolina. The conference was held July 13–15, 1995. Earlier, results from this the effort had been presented at a ONR 6.1 Virtual Environment Grantees Workshop, in March of 1995.

(B) Feature Based Design with Ereps (Hoffmann)

The Erep project, also supported by ONR under contracts N00014-90-J-1599 and N00014-96-1-0635, has developed an information model of a high-level, feature-based design representation. This ongoing effort has had significant impact on the field of solid modeling, and on both academic research and commercial CAD development. For example, the Erep work was extended by the industry-led ARPA ENGEN Project, administered through ONR and awarded to an industry consortium led by the South Carolina Research Authority to develop the exchange of constraints between commercial CAD systems.

During the support period, the project explored issues of spatial constraint solving, an enabling technology for next generation CAD, and issues related to user-defined features. Current work is developing an object-oriented design repository framework, a so-called master model. This new initiative is also showing signs of string impact: Hoffmann will present some of the results of this work at the upcoming Aerospace Interest Group meeting in Arizona, January 1998, and participate in discussions setting strategic directions for CAD developments for the next five years.

3 Publications, Reports, and Presentations

3.1 Reports, Papers, Book Chapters

1. G. Vanecek, "Back-face Culling Applied to Collision Detection of Polyhedra," *J. of Visualization and Computer Animation 5*, 1994, 55-63.

2. G. Vanecek, "Modeling Contacts in a Physical Based Simulation," *CAD 26*, 1994, 452–464; (with W. Bouma).

3. G. Vanecek, "Velocity Based Collision Detection," *Graphics Gems V*, Academic Press 1995, 380–385; (with W. Bouma).

4. G. Vanecek, "Spatial Partitioniong of a Polygon by a Plane," *Graphics Gems V*, Academic Press 1995, 386–393.

5. G. Vanecek, "Locally Resolvable B-reps," Technical Rept, Purdue University, CSD 94-76, 1994; (with C. Gonzalez-Ochoa).

6. G. Vanecek, "Incremental Construction of Multi-dimensional Space Partitioning Trees," Technical Rept, Purdue University, CSD 94-77, 1994; (with S. Shastry).

7. C. Hoffmann, "Towards Feature Attachment," *CAD 27*, 1995, 695–702; (with X. Chen).

8. C. Hoffmann, "On Editability of Feature Based Design," *CAD 27*, 1995, 905–914; (with X. Chen).

9. C. Hoffmann, "Geometric Constraint Solving in $\mathbf{R}^2$ and $\mathbf{R}^3$," in *Computing in Euclidean Geometry*, second edition, D. Z. Du and F. Hwang, eds., World Scientific Publishing, 1995, 266–298; (with P. Vermeer).

10. C. Hoffmann, "A Geometric Constraint Solver," *CAD 27*, 1995, 487–501; (with W. Bouma, I. Fudos, J. Cai, W. Paige).

11. C. Hoffmann, "A Spatial Constraint Problem," *Computational Kinematics '95*, J.-P. Merlet and B. Ravani, eds., Kluwer Academic Publ., 1995, 83–92; (with P. Vermeer).

12. C. Hoffmann, "Geometric Constraints in CAGD", in *Mathematical Methods in CAGD III*, M. Dahlen, T. Lyche, and L. Schumaker, eds, 1995, 237–254; (with J. Peters).

13. C. Hoffmann, "Generic Naming in Generative, Constraint-Based Design," *CAD 28*, 1996, 17–26; (with V. Capoyleas and X. Chen).

14. C. Hoffmann, "Constraint-Based Parametric Conics for CAD," *CAD 28*, 1996, 91–100; (with I. Fudos).

3.2 MS and PhD Thesis

Ramanathan Kavasseri, "The Apollonius Problem," MS, 1996.

3.3 Presentations at Conferences and Workshops

1. G. Vanecek, "Isaac: Building Simulation Environments for Virtual Environments," IFIP Workshop on Virtual Environments, Coimbra, Portugal, October 1994.

2. G. Vanecek, "Proxima: Geometric Support for Virtual Environments," ONR 6.1 Virtual Environment Grantee Workshop, Arlington, March 1995.

3. C. Hoffmann, "Feature Compilation," NIST/RRM Workshop on Feature-Based Design, Detroit, August 1995.

4. C. Hoffmann, "Erep Project Overview," CAD tools for products, Schloss Dagstuhl, Germany, September 1995.

5. C. Hoffmann, "A Spatial Constraint Solving Problem," Workshop on Computational Kinematics, Sophia-Antipolis, France, September 1995.

6. C. Hoffmann, "Semantics of Solid Modeling," IFIP Workshop on Product Design, Airlie Foundation, Washington DC, May 1996.

7. C. Hoffmann, "How Solid is Solid Modeling?" ARO Workshop on Applications of Computational Geometry, Philadelphia, May 1996.

8. C. Hoffmann, "Geometric Mesh Generation," Workshop on Computational Fluid Dynamics, Princeton, July 1996.

3.4 Workshops and Conferences Organized

1. G. Vanecek, Workshop on Simulation of Virtual Environments, Purdue University, July 21–23, 1994 (with J. Cremer).

2. G. Vanecek, Workshop on Simulation and Interaction in Virtual Environments, University of Iowa, July 13–15, 1995 (with J. Cremer and D. Manocha).

3. C. Hoffmann, 3rd ACM Symposium on Solid Modeling, Salt Lake City, 1995; (with J. Rossignac).